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KARST AQUIFER IN MT GALIČICA AND POSSIBILITES FOR WATER SUPPLY TO OHRID WITH GROUND-WATER

Vojo Mirčovski[1] , Aleksandar Kekić[2], Orce Spasovski[1], Vlado Mirčovski[1]

[1]*Faculty of Natural and Technical Sciences, "Goce Delčev" University, Goce Delčev 89, MK-2000 Štip, Republic of Macedonia*
[2]*Geohydroproject, MK-1000 Skopje, Republic of Macedonia*
vojo.mircovski@ugd.edu.mk

A b s t r a c t: In this paper are presented some hydrogeological features of the karst aquifer in Mt Galičica, which contains important quantities of ground-water that can to used for the water supply of the town Ohrid. Based on the hydrogeological data are given three solutions that be can to used for water suply of Ohrid, the first one is to drill of deep wells, combination of deep and shallow wells, as well as construction of horizontal galleries.

Key words: karst aquifer; Mt Galičica; Triassic limestones; water supply; Ohrid

INTRODUCTION

The karst aquifer in Mt Galičica is situated in the southwest of the country between Lake Ohird and Lake Prespa (Fig 1). Part of it extends further to the territory of Albania and one to the territory of neighhbouring Greece. It is one of the largest karst aquifers in west Macedonia and plays an important role for the water supply of the town of Ohrid and maintains the water table of Lake Ohrid.

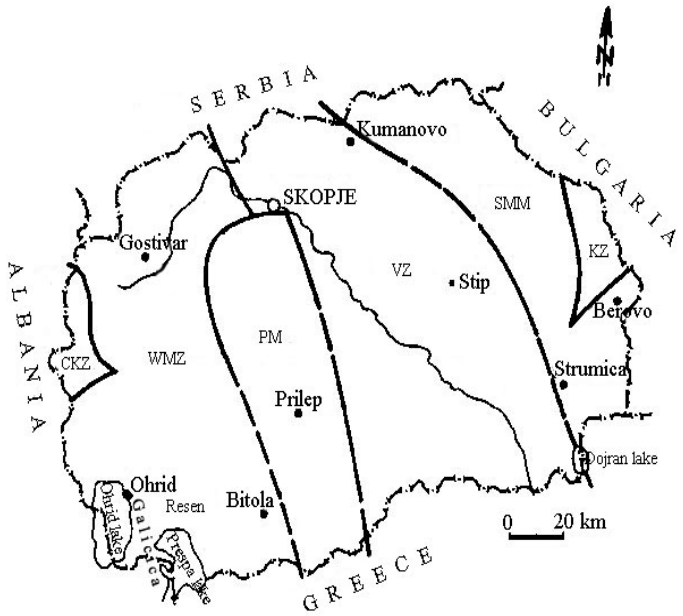


Fig. 1. Geotectonic map of the Republic of Macedonia and the position of the Mt Galičica (M. Arsovski, 1997).
WMZ – Western Macedonian zone, PM – Pelagonian massive, VZ – Vardar zone, SMM – Serbo-Macedonian massive, CKZ – Cukali–Krasta zone, KZ – Kraistide zone.

GEOLOGICAL FEATURES

Investigated area is part of the Western Macedonian zone (Fig 1), (Арсовски, 1997). The geology of the wider area of Mt Galičica is shown in the Geological map (Fig.2) (Думурџанов, Ивановски, 1972, 1973).

The geology of the surrounding of the aquifer consists of Paleozoic, Mezosoic, Tertiary and Quaternary rocks (Думурџанов, Ивановски, 1972, 1973, 1978; Ивановски, 1958,).

Paleozoic is present of sienites (ξ), granodiorites (δγ), metasandstones (sq), quartz-sericitic schists (Sqse).

The mezosoic roks are present of Triassic massive limestones ($T_2^{1,2}$), sandstones, slates, conglomerates (T_2^1) and jurasic dijabases (ββ) and peridotite and serpentinite (oSe).

Tercier is made up of gravels, sands and cley (pl_3), gravels, sands and cley and marls (pl_2).

Quarter is present of alluvium (al), proluvium (pr), delluvium (d), tera rosa (ts); glaciofluvial sediments (fgl) and limnic sediment (j).

Mt Galičica is a horst built of Triassic massive karstified limestones overlying Paleozoic metamorphic rocks present as quartz-sericite-phyllite schists, sporadically as metasandstones.

HYDROGEOLOGICAL FEATURES

The area of the Triassic limestones in Galičica is some 200 km^2. Limestones are highly fissured and karstified with Paleozoic water impermeable schists at the foot. This makes possible the formation of karst fracture aquifers in them. Recharge of the aquifer is done by surface waters (rain water) that infiltrate through fractures, caverns, whirlpools and other vugs as well as by the water form Lake Prespa that flows underground to Lake Ohrid since Lake Prespa is situated at 160 m higher sea level than Lake Ohrid (Amataj et al., 2005)

Hydrogeological investigations carried out so far indicate that this karst-fracture type of aquifer formed in the Galičica limestones is characterized by deep karstification.

Outlet of water has been seen as many springs at the eastern and western banks of Lake Ohrid or underground.

The largest discharge the capacity of 5 – 9.5 m^3/s is at the spring at St. Naum, 0.2 – 1 m^3/s at Biljanini Izvori, 40 – 100 l/s at Bei Bunar. It is assumed that less 1 m^3/s of water flow into the lake.

For the determination of water permeability, the degree of karstification, depth and the relationship between limestones and schists in the Galičica karst, several exploration drill holes were drilled close to the shore not far from Biljanini Izvori. (Кекиќ, 1978).

Exploration drill holes showed that the Triassic limestones at the foot of the mountain on the way to the lake are from 48 to 100 m thick. Exploration drill holes in limestones indicated that higher karstification degree could be found as far as the water impermeable base. Average porosity estimated based on investigation is from 15 to 20%.

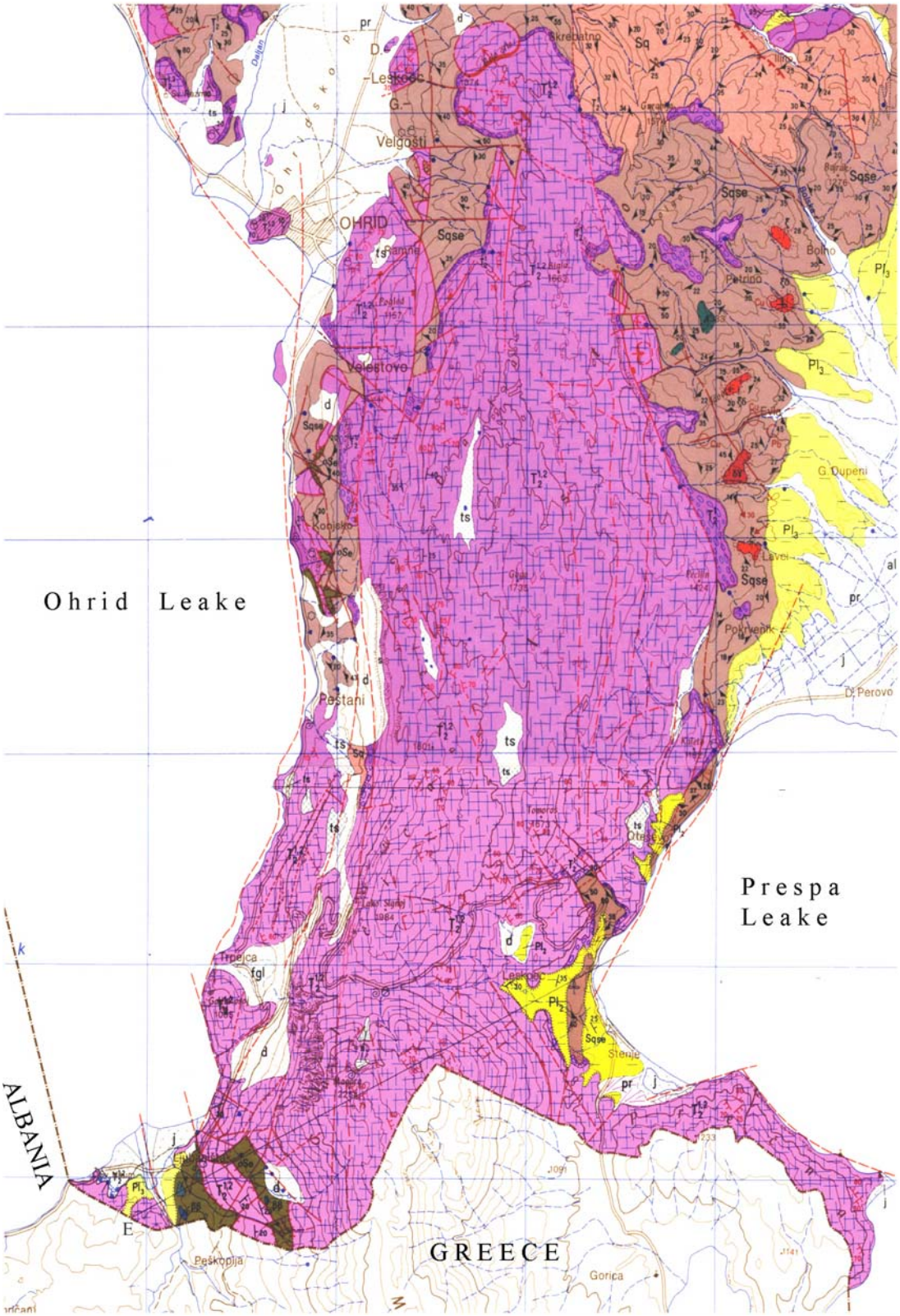
WATER QUALITY

Water quality was studied with several chemical analyses for several karst springs. According to hardness which is from 7.4–10.8 degrees the water is classified as medium hard, whereas according to the chemical composition it is calcic bicarbonate.

According to Alekin's classification it is hydrocarbonate and belongs to the calcic group.

Total mineralization amounts from 244.6 to 325.6 mg/l and belongs to the poorly mineralized water.

pH value is from 6.6 to 7.5 and the water belongs to the neutral group of waters.



Quaternary: al – alluvium; **pr** – proluvium; **d** – deluvium; **ts** – tera rosa; **fgl** – glaciofluvial sediments; **j** – limnic sediment. **Tercier: pl_3** – gravels, sands and cley; **pl_2 –** gravels, sands and cley and marls. **Jurassic: ββ –** dijabases**; oSe –** peridotite and serpentinite; **Triassic:** $T_2^{1,2}$ – massive limestones; T_2^1 – sandstones, slates, conglomerates. **Paleozoic** (Devon)**: ξ –** sienites; **δγ** – granodiorites; **sq** – metasandstones; **Sqse** – quartz-sericitic schists (phyllite schists)

Fig. 2. Geological map of the area of Mt Galičica

POSSIBILITIES FOR A LONG-TERM WATER SUPPLY OF OHRID FROM THE KARST AQUIFER IN MT GALIČICA

The results obtained during hydrogeological investigations indicate that the karst in Mt Galičica contains significant amount of ground-water that recharge Lake Ohrid either underground or on the surface by waters that come out of numerous springs of variable yield such as Sveti Naum, Biljanini Izvori, Bej Bunar. In addition, large quantities of water are "captured" in the off shore karst towards Ohrid valley as deep ground accumulations. Explorations have also shown that the Galičica karst contains water at various depths.

According to the results obtained, including earlier results, for the understanding of the hydrogeological features of karstified limestones in Galičica, three possible solutions can be suggested in connection with the issue of water supply of Ohrid (Fig 3):

1. Deep wells,
2. Combination between deep and shallow wells,
3. Free gravitation and developing horizontal galleries

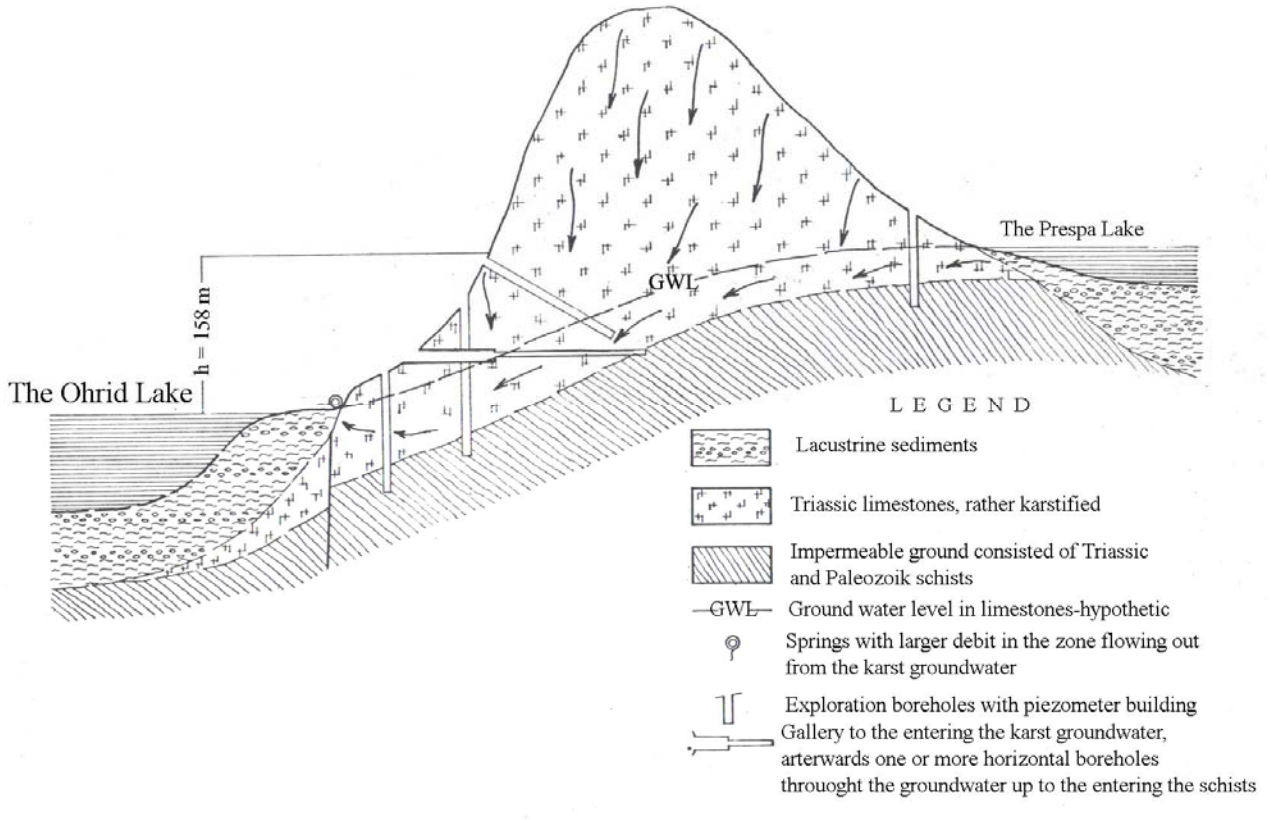


Fig. 3. Shematic hydrogeological profile from the Ohrid to the Prespa Lake across the Galičica mountain. The variant for a long-term water supply of the town Ohrid from the Galičica karst aquifer.

Deep wells

Water obtained from exploitation well 60 m at depth and the small lowering the level of the aquifer doing test drawdown (particularly during summer and autumn) indicate that drilling several deep well is a possible solution in obtaining large amounts of water for water supply system of Ohrid.

Combination of deep and shallow wells

Data obtained for small lowering the dynamic level in shallow wells during test drawdown and during exploitation and the high level of groundwaters at the Biljanini Izvori – Bej Bunar strike indicate that it is possible to dig shallow wells combined with deep wells. The number will depend on the amount of water needed.

Free gravitation and developing horizontal galleries

Favorable field conditions and the high ground-water potential make it possible to use ground-waters as free gravitation by making one or more galleries. The first possibility is the galleries to be made 80 m above the Ohrid Lake level before they enter the karst aquifer waters and water capture by horizontal drill holes in water bearing surrounding. The second possibility is the entire length of the galleries to involve the water bearing surrounding as far as water impermeable base.

CONCLUSION

Investigations carried out so far indicate that karstification of the Triassic limestones in Galičica is deep as far as water impermeable Paleozoic schists.

The aquifer contains important amounts of ground water, part of which is used for the water supply of Ohrid and is very promising for future water supply.

Analyses indicate that the best solution for the permanent water supply of Ohrid is the use of karst aquifer ground waters of drilling of deep wells, combination of deep and shallow wells as well as with free gravitation by the construction of horizontal galleries.

It is necessary to pay greater attention to water management and to the issue of protection of the waters against contamination.

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Р е з и м е

КАРСНИОТ ВОДОНОСНИК НА ПЛАНИНАТА ГАЛИЧИЦА И МОЖНОСТИ ЗА ВОДОСНАБДУВАЊЕ НА ОХРИД СО ПОДЗЕМНА ВОДА

Војо Мирчовски[1], Александар Кекиќ[2], Орце Спасовски[1], Владо Мирчовски[1]

[1]Факултет за природни и технички науки, Институт за Геологија, Универзитет „Гоце Делчев“ ул. Гоце Делчев 89, МК-2000 Штип, Република Македонија
[2]Геохидропроект, МК-1000 Скопје, Република Македонија
vojo.mircovski@ugd.edu.mk

Клучни зборови: карстен водоносник; планина Галичица; тријаски варовници; водоснабдување; Охрид

Во овој труд се прикажани некои хидрогеолошки карактеристики на карсниот водоносник на планината Галичица, во кој се акумулирани значителни количества подземна вода, која може да се искористи за водоснабдување на градот Охрид.

Врз основа на хидрогеолошките податоци, предложени се три варијантни решенија кои можат да се искористат за водоснабдување на Охрид првата варијанта е со изработка на длабоки бунари потоа комбинација на длабоки и плитки бунари, или пак со изработка на хоризонтални галерии.